

Attorney Docket No. 82517
Customer No. 23523

MOUNTABLE SYNTACTIC FOAM SENSOR HOUSING

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) PATRICK J. MONAHAN and (2) ROBERT S. JANUS, employees of the United States Government, citizens of the United States of America, and residents of (1) Gales Ferry, County of New London, State of Connecticut, and (2) Middletown, County of Newport, State of Rhode Island have invented certain new and useful improvements entitled as set forth above of which the following is a specification.

MICHAEL P. STANLEY, ESQ.
Reg. No. 47108
Naval Undersea Warfare Center
Division, Newport
Newport, RI 02841-1248
TEL: 401-832-4736
FAX: 401-832-1231

2
3 **MOUNTABLE SYNTACTIC FOAM SENSOR HOUSING**

4
5 **STATEMENT OF GOVERNMENT INTEREST**

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 governmental purposes without the payment of any royalties
9 thereon or therefor.

10
11 **BACKGROUND OF THE INVENTION**

12 **(1) Field of the Invention**

13 The field to which this invention relates is hull mounted
14 acoustic sensor modules for towed array handling systems.

15 **(2) Description of the Prior Art**

16 During some submarine operations, a towed array for
17 underwater acoustic reception extends by tow cable from the hull
18 of the submarine. After use, the towed array is retrieved using
19 an exterior retrieval system. Since the retrieval system is
20 exterior to the submarine hull or otherwise separated from
21 direct access by submarine personnel, acoustic sensors are used
22 to detect retrieval of the towed array.

23 Typically, the acoustic sensors surround a passage tube in
24 which the towed array is retrieved through a water-filled inner

1 volume of the passage tube. The basic sensor design consists of
2 an acoustic projector and a receiver. These two units are
3 typically positioned on opposite sides of the passage tube. The
4 projector transmits an acoustic beam which is detected by the
5 receiver. The difference in signal level detected by the
6 receiver when the towed array is/is not between the projector
7 and receiver is used to determine when the array has been
8 completely retrieved.

9 The acoustic sensors surrounding the passage tube are
10 encased in a copper-nickel housing in order to position the
11 sensors. The housing also provides a watertight enclosure that
12 prevents exterior water from reaching the sensors and the
13 interior components. Exterior water, typically in the form of
14 seawater, can damage the sensors by corrosion or by the
15 electrical conductivity associated with seawater. As such, the
16 module must be water-resistant as possible and optimally
17 watertight. For a metal module, a watertight condition requires
18 multiple o-rings at the apertures and connection points of the
19 module. However, the use of multiple o-rings increases the
20 likelihood of problems associated with o-rings such as
21 unpredictable failure and increasing replacement costs.

22 Also, because most sensors and their support components
23 require periodic maintenance, the metal housing containing the
24 sensors must be removed from the submarine and accessed. Since

1 a metal module and interior housing is heavy and awkward for
2 handling underwater, the module is often difficult for divers to
3 remove and re-position during maintenance.

4 SUMMARY OF THE INVENTION

5 Accordingly, it is a general purpose and primary object of
6 the present invention to provide a watertight acoustic sensor
7 module for detecting when a towed array has been fully retrieved
8 by its handling system in which the acoustic sensor module
9 maintains its watertight integrity without the use of o-rings

10 It is a further object of the present invention to provide
11 a light-weight watertight acoustic sensor module.

12 It is a still further object of the present invention to
13 provide a watertight acoustic sensor module of easy fabrication
14 and relatively low cost.

15 To attain the objects described there is provided a
16 composite encapsulation method for an acoustic sensor module and
17 a resultant lightweight watertight acoustic sensor module for
18 towed array handling systems.

19 Prior to encapsulation, the component structure of the
20 acoustic sensor module generally comprises two end plates
21 removably connected by support posts to each other in which the
22 end plates encompass a passage tube. Four transducers are

1 attached to the passage tube at positions equidistant from each
2 other on the circumference of the passage tube.

3 Each of the transducers is attached to the passage tube by
4 a semi-rigid adhesive with an acoustic window that allows an
5 acoustic beam to be transmitted from a piezoelectric ceramic
6 element of two transducers onto the passage tube. A backing
7 plate of the transducers further directs the acoustic beam to
8 the passage tube. For the other two transducers, the acoustic
9 window of the adhesive allows an acoustic beam to be received
10 from the passage tube by the piezoelectric ceramic element of
11 the transducers.

12 Telemetry lines from the transducers are conductive to an
13 electrical conductor fitted in an aperture of one of the two end
14 plates. The electrical conductor is attachable to an external
15 signal generator that drives the two acoustic projectors and to
16 a circuit that monitors the output levels of the acoustic
17 receivers.

18 In the composite encapsulation method, an epoxy composite
19 is injected into a cast. The epoxy composite is injected to
20 encapsulate the support posts, the exterior of the passage tube,
21 the transducers and the telemetry lines of the acoustic sensor
22 module. A resin with micro-spheres is added to further lighten
23 the weight of the acoustic sensor module. Once the epoxy
24 composite with a micro-sphere resin is mixed, hollow glassine

1 macro-spheres are added to the composite such that a composite
2 with a syntactic construction results. The syntactic composite,
3 in addition to being lighter than the epoxy composite, is also
4 highly resistant to external pressure and impact forces.

5 The components, listed above, of the acoustic sensor module
6 can be cast into a resultant light-weight block of the epoxy
7 composite with or without micro-spheres and macro-spheres. The
8 casting sets the arrangement of the components thereby
9 minimizing vibration of the components.

10 The residual epoxy composite or syntactic composite
11 emitting from the aperture of the end plate allows the
12 electrical conductor to be potted directly into the composite
13 thereby eliminating the need for sealing O-rings and reducing
14 the chances of water penetration. Additionally, the need for
15 tooling the acoustic sensor module to allow O-ring placement is
16 eliminated, thereby greatly reducing the cost of fabrication.

17 The above and other features of the invention, including
18 various and novel details of construction and combinations of
19 parts will now be more particularly described with reference to
20 the accompanying drawings and pointed out in the claims. It
21 will be understood that the particular devices embodying the
22 invention are shown by way of illustration only and not as the
23 limitations of the invention. The principles and features of

1 this invention may be employed in various and numerous
2 embodiments without departing from the scope of the invention.

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 A more complete understanding of the invention and many of
6 the attendant advantages thereto will be readily appreciated as
7 the same becomes better understood by reference to the following
8 detailed description when considered in conjunction with the
9 accompanying drawings wherein:

10 FIG. 1 is a side view of the acoustic sensor module of the
11 present invention with the composite section and macro-spheres
12 removed for the purpose of depicting a clarified view of the
13 sensor geometry;

14 FIG. 2 is a plan view of the acoustic sensor module of the
15 present invention with the epoxy section and macro-spheres
16 removed for the purpose of depicting an alternative clarified
17 view of the sensor geometry, with the view taken from reference
18 line 2-2 of FIG. 1;

19 FIG. 3 is a plan view of the end plate of the acoustic
20 sensor module of the present invention, with the view taken from
21 reference line 3-3 of FIG. 1;

22 FIG. 4 is a diagram of the operation of the acoustic sensor
23 module of the present invention;

1 FIG. 5 is a perspective view of the acoustic sensor module
2 of the present invention depicting the addition of encapsulating
3 composite and macro-spheres; and

4 FIG. 6 is a side view of the acoustic sensor module of the
5 present invention fully assembled.

6 DESCRIPTION OF THE PREFERRED EMBODIMENT

7 Referring now to the drawings wherein like numerals refer
8 to like elements throughout the several views, one sees that
9 FIGS. 1 and 2 depict the acoustic sensor module 10 of the
10 present invention. The module 10 generally comprises the
11 components of two end plates 12, 14 connected to each other by
12 support posts 16, 18, 20 and 22 which encompass a passage tube
13 24. Four transducers 26, 28, 30 and 32, with an electrical
14 conductor 33, are attached to a passage tube 24 at positions
15 equidistant from each other on the circumference of the passage
16 tube.

17 Each of the transducers 26, 28, 30 and 32 is attached to
18 the passage tube 24 by a semi-rigid adhesive, such as
19 polyurethane. Polyurethane is preferred in that the material is
20 acoustically transparent as an acoustic window 42 for a
21 piezoelectric ceramic element 44. The acoustic window 42 allows
22 an acoustic beam to be transmitted from the piezoelectric
23 ceramic element 44 of the transmit transducers 26 and 28 onto

1 the passage tube 24. A backing plate 46 of the actuated
2 transducers 26 and 28 further directs the acoustic beam to the
3 passage tube 24.

4 For the receive transducers 30 and 32, the acoustic window
5 42 allows an acoustic beam to be received from the passage tube
6 24 by the piezoelectric ceramic element 44 of the transducers.
7 The backing plate 46 of the transducers 30 and 32 further
8 enhances the acoustic beam from the passage tube 24 to the
9 piezoelectric ceramic element 44. The operation of the
10 transducers 26, 28, 30 and 32 during a towed array retrieval is
11 discussed in further detail below.

12 The transducers 26 and 28 are wired together in parallel
13 with telemetry lines 48 and as stated above, and perform as
14 acoustic projectors which transmit acoustic beams into the
15 passage tube 24. The transducers 30 and 32 are also wired
16 together in parallel by another set of the telemetry lines 48
17 and as stated above perform as hydrophones which receive the
18 acoustic beams of the transducers 26 and 28. The telemetry
19 lines 48 are conductive to the electrical conductor 33 fitted in
20 an aperture 34 of the end plate 12. (See FIG. 3) The electrical
21 conductor 33 is attachable to a signal generator 60 and to a
22 receive signal circuit 62 which are depicted diagrammatically in
23 FIG. 4.

1 As shown in FIG. 3, the end plate 12 is suitably designed
2 for mounting in a submarine. The thickened semi-circular end
3 plate 12 includes three protruding guides 51 sized to fit slots
4 within the mounting structure of the submarine (not shown).

5 Referring again to the diagram of FIG. 4 for the operation
6 of the acoustic sensor module 10, the signal generator 60, such
7 as an oscilloscope, transmits a continuous wave (CW) signal over
8 the telemetry lines 48 to actuate the transducers 26 and 28.

9 The piezoelectric ceramic elements 44 of the transducers 26 and
10 28 vibrate in response to the continuous wave signal. The
11 vibration of the piezoelectric ceramic elements 44 projects an
12 acoustic beam through the acoustic window 42 and into an inner
13 volume of the passage tube 24. Since the transducers 26 and 28
14 are perpendicular to each other, a cross-beam pattern 63 that
15 includes the single beams of both transducers is formed in the
16 passage tube 24. As a towed array cable 64 is retrieved in a
17 water column of the passage tube 24, the cross-beam pattern 63
18 is partially deflected by the towed array cable and is received
19 as partially deflected by the hydrophone capacity of the
20 transducers 30 and 32.

21 When the acoustic energy of the partially-deflected cross-
22 beam pattern 63 is received by the piezo-ceramic elements 44 of
23 the transducers 30 and 32, the acoustic energy is converted to
24 electrical energy. The voltage of the electrical energy

1 produced by the piezoelectric ceramic elements is transmitted to
2 the receive signal circuit 62. The predetermined voltage
3 received by the receive signal circuit 62 indicates whether or
4 not a towed array is present in the passage tube 24.

5 During a towed array retrieval, the receive signal circuit
6 62 signals a winch (not shown) to keep pulling in the towed
7 array as long as the predetermined voltage is received by the
8 controller. When the end of the towed array has continued past
9 the transducers 26, 28, 30 and 32, a full or non-deflected
10 cross-beam pattern is transmitted through the passage tube 24
11 and is received by the transducers 30 and 32. The acoustic
12 energy of the full or non-deflected beam received by the
13 piezoelectric ceramic elements 44 of the transducers 30 and 32
14 and the resultant voltage transmitted by the piezoelectric
15 ceramic elements 44 is received by the receive signal circuit
16 62. The resultant voltage indicates that the towed array is no
17 longer present in the passage tube 24 which prompts the receive
18 signal circuit 62 to stop the winch and to stop retrieval of the
19 towed array.

20 In the composite encapsulation method of the acoustic
21 sensor module 10 shown in FIG. 5, an epoxy composite 70, is
22 injected into a cast 71. The epoxy composite 70 is injected
23 into the cast 71 to encapsulate the support posts 16, 18, 20 and
24 22; the exterior of the passage tube 24; the transducers 26, 28,

1 30 and 32; and the telemetry lines 48 of the acoustic sensor
2 module 10. The epoxy composite 70 preferred for casting is LORD
3 305 epoxy. LORD 305 epoxy is identifiable by the its ability to
4 mix with resin micro-spheres 72 which contain hollow micro-
5 spheres which contribute to its light weight. Other suitable
6 substitutes of epoxy, known to those ordinarily skilled in the
7 art, may be used; however, differences in texture and weight may
8 be encountered such that different casting methods may be
9 required.

10 Once a epoxy composite 70 with the resin micro-spheres 72
11 is mixed, hollow glassine macro-spheres 73 are added to the
12 composite such that a composite 74 with a syntactic construction
13 results. The syntactic composite 74, in addition to being
14 lighter than the epoxy composite 70, is also highly resistant to
15 the pressure and impact forces. The components, listed above,
16 of the acoustic sensor module 10 are cast into a resultant
17 light-weight block 76 of the epoxy composite 70 with or without
18 micro-sphere resin 72 and macro-spheres 73. See FIG. 6 The
19 light-weight block 76 sets the arrangement of the components in
20 place.

21 The residual epoxy composite 70 or syntactic composite 74
22 emitting from the aperture 35 of the end plate 12 allows the
23 electrical conductor 33 to be potted directly into the composite
24 thereby eliminating the need for sealing O-rings and reducing

1 the chances of water penetration. Additionally, the need for
2 tooling the acoustic sensor module 10 to allow O-ring placement
3 is eliminated, thereby greatly reducing the cost of fabrication.

4 Accordingly, the epoxy casting of the acoustic sensor
5 module 10 of the present invention provides a simple,
6 inexpensive means for a significantly lightened acoustic sensor
7 module with an enhanced water-tightness around its electrical
8 components.

9 Thus by the present invention its objects and advantages
10 are realized and although preferred embodiments have been
11 disclosed and described in detail herein, its scope should be
12 determined by that of the appended claims.